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(54) **Circuit arrangement.**

(57) The invention relates to a circuit arrangement for operating a discharge lamp (L) with a substantially constant power P_L by means of a switch mode power supply with variable input current I_o and provided with periodically switching switching means (10) for controlling the variable input current by means of a drive signal. The drive signal generated in a drive circuit (V) is formed from a signal S1 which is proportional on the one hand to the input current and on the other hand to the lamp voltage V_L and a reference signal. The circuit arrangement comprises means (IV) for generating signal S1. The power P_L by good approximation thereby satisfies the relation

$P_L = V_b I_o - K_2/V_L$

in which
V_b = supply source voltage
V_L = lamp voltage
K_2 = proportionality constant.

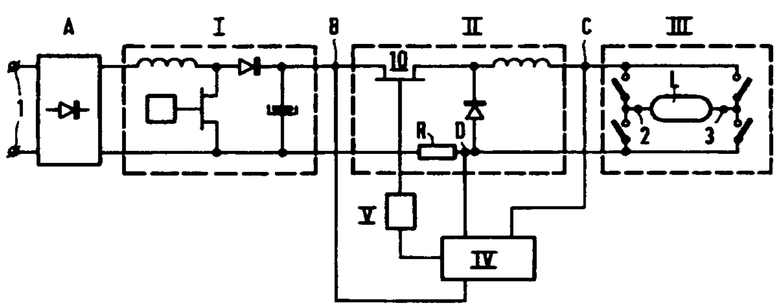

FIG.1

EP 0 507 399 A2

The invention relates to a circuit arrangement for operating a discharge lamp at a substantially constant power by means of a switch mode power supply having a variable input current and provided with switching means which switch periodically for controlling the input current by means of drive signal generated in a drive circuit and formed from a signal S1 which is proportional to the input current and a reference signal, which circuit arrangement comprises means for generating the signal S1.

A circuit arrangement of the kind mentioned in the opening paragraph is known from USP 4,928,038. It is achieved in the known circuit arrangement by good approximation that the connected lamp is operated at a constant power. This is important for maintaining a desired colour temperature T_c of the light radiated by the lamp. This is achieved in the known circuit arrangement, which has a down-converter as the switch mode power supply, in that the pulsatory current through the switching means is measured and the measurement signal obtained in this way is used as a feedback signal in the drive circuit for generating the drive signal for driving the switching means. The circuit arrangement is also suitable in the case in which the power at which the lamp is operated is itself adjustable, for example, for dimming of the lamp. If a different type of switch mode power supply is used, the input current will also be dependent on the switching of the switching means, but it need not necessarily be identical to the current through the switching means, neither need it necessarily be pulsatory. In such a case both a measurement of the input current and a measurement of the current through the switching means is suitable for obtaining the measurement signal. An advantage of the known circuit arrangement is that a comparatively simple control system is realised whereby the variations of the operating characteristics of the lamp need not be registered. A disadvantage of the control of the known circuit arrangement, however, is that fluctuations of up to approximately 3% occur in the lamp power, which are found in practice to lead to sometimes substantial differences in the colour temperature T_c.

Accordingly, the invention has for its object to provide a measure by which variations in colour temperature of the operated lamp as a result of power fluctuations are considerably restricted, while the simplicity of the control system is maintained.

A circuit arrangement of the kind mentioned in the opening paragraph is for this purpose characterized in that it comprises means by which the signal S1 is also given a dependence on the lamp voltage V_L.

It was surprisingly found to be possible to stabilize the lamp power accurately to within 1% over a wide range of occurring lamp voltages. Thus it was experimentally ascertained that, with a lamp voltage which was approximately 35% above the rated value, a power variation of no more than 0,8% took place. An important aspect of the measure according to the invention is that dissipations in the circuit arrangement resulting from a changing value of the lamp current are compensated for. This may be mathematically illustrated as follows. US Patent 4,928,038 discloses the relation between input power P_{in}, pulsatory input current I_o averaged in time, and supply source voltage V_b:

$$P_{in} = V_b \cdot I_o \qquad (1)$$

It is also generally known that the lamp power P_L depends on the efficacy η of the circuit arrangement, which is mathematically expressed as:

$$P_L = \eta P_{in} \qquad (2)$$

Assuming that the power difference $P_{in} - P_L = P_{dis}$ is dissipated in the circuit arrangement, this can be represented by the relation

$$P_{dis} = K_1 I_L \qquad (3)$$

In which I_L is the lamp current and K_1 the voltage difference owing to the impedance causing the dissipation. Starting from the desired constant value of the lamp power $P_L = V_L I_L$, relation (3) can be rewritten as

$$P_{dis} = K_2/V_L \qquad (3a)$$

A relation for the lamp power is derived through combination of relation (1) and relation (3), as follows:

$$P_L = V_b I_o - K_2/V_L \qquad (4)$$

The drive of the periodically switching means is corrected for the dissipation occurring in the circuit

arrangement through the addition to the signal S1 of a signal portion proportional to $1/V_L$.
Although it can be derived from the above description that dissipations in the circuit arrangement depend on the value of the lamp current I_L, it is preferable to use the lamp voltage V_L for the control. Measurement of the lamp voltage V_L can take place substantially without dissipation. By contrast, the generation of a signal proportional to the lamp current I_L will in practice lead to the choice for the use of a measuring resistor in the circuit portion traversed by the lamp current I_L for reasons of simplicity, reliability, and cost price. This accordingly results in further dissipation, which is undesirable.

It is true that the circuit arrangement according to the invention comprises an expanded measurement signal, so an expanded drive circuit compared with the known circuit arrangement. The nature of the expansion, however, means that a simple summation of two signal voltages can suffice. This can be realised in a very simple manner and at very low cost with generally known and available electronic components. The essence of the drive circuit remains intact then, and the advantage of a simple control system is not impaired.

The conservation of a simple control system becomes even more apparent upon closer consideration of relation (4), where the inventor has found that the term K_2/V_L in the signal S1 represents a minor correction of the portion of the signal S1 corresponding to the term $V_b I_o$. This renders it possible to replace the relation (4) with

$$P_L = V_b I_o + V_L/K_3 - C \qquad (5)$$

in which K_3 and C are constants. Means for generating the signal S1 may be very simply constructed, on the basis of the relation (5) found, from an electric circuit for summation of signal voltages representing I_o and V_L and in which resistors serve to achieve the desired adjustment to represent the constant quantities V_b, K_3 and C.

A further improvement can be achieved in that the actual value is also used for V_b in the generation of the signal S1. It is achieved in this way that a disturbance of the value of V_b is also corrected and that thus the power consumed by the lamp is substantially fully insensitive to such a disturbance. For practical purposes, the product $V_b I_o$ can be very well represented by a summation $V_b + I_o$. The simple character of summation of signal voltages is maintained thereby for the construction of the circuit arrangement for generating the signal S1.

The circuit arrangement according to the invention is particularly suitable for operating a metal halide lamp. It is found in practice that metal halide lamps have a wide variation in actual lamp voltages. Thus it is usual for the actual lamp voltage to vary between 75 V and 115 V while the rated lamp voltage is 85 V.

An embodiment of a circuit arrangement according to the invention will be explained in more detail below with reference to a drawing in which

Fig. 1 is a diagram of a circuit arrangement according to the invention together with a connected lamp, and

Fig. 2 shows a detailed view of means for generating a signal S1.

In Fig. 1, reference numeral 1 denotes connection terminals for connecting a supply source, for example, a 220 V, 50 Hz AC voltage source. The circuit arrangement comprises in that order a rectifier circuit A, an up-converter I, a down-converter II, and a commutator network III. The down-converter fulfils the function of switch mode power supply. A lamp L is included between lamp connection terminals 2, 3 in the commutator network 3. The lamp is included in the commutator network in order to counteract cataphoresis during operation. The rectifier circuit A may also comprise a filter circuit of a type known *per se* to prevent undesirable distortions of the current drawn from the supply source. The DC current formed by the rectifier circuit A is transformed in the up-converter I to a DC voltage of 385 V and acts as the supply source voltage V_b for the down-converter II. The down-converter II acts as a current source and operates the commutator network with connected lamp by deriving a pulsatory current from the supply source, for which purpose it comprises periodically switching switching means 10, for example a MOSFET. The switching means 10 are driven by a drive signal generated in a drive circuit V and formed from a signal S1 proportional to the pulsatory input current and a reference signal. Signal S1 also comprises a dependence on lamp voltage V_L. The circuit arrangement comprises means IV to be referred to as signal means hereinafter for generating the signal S1.

The supply source voltage V_b is measured at B and conducted to signal means IV. Similarly, the lamp voltage V_L is measured at C and conducted to signal means IV. A measuring resistor R is included in down-converter II, through which resistor the pulsatory current I_o flows. This causes a voltage differential across the measuring resistor R which is measured at D and conducted to signal means IV.

In Fig. 2, the signal means IV are shown in more detail. The signal means IV comprise an operational

amplifier 4 for comparison of a signal S1 with a reference signal which is present at input 4a as a voltage V_{ref}. The signal S1, which was obtained through summation of the signal voltages at B, C and D, is present at an input 4. The desired adjustment takes place by means of the resistors 5, 6 and 7 in order to represent the mutual ratios necessary for the summation. The difference between signal S1 and the reference signal is integrated by means of capacitor 8 and conducted to the drive circuit V through output 4c of the operational amplifier.

In a practical realisation of the embodiment described, the circuit is operated at a 220 V, 50 Hz AC voltage source. The up-converter I supplies a DC voltage of 385 V which acts as the supply source voltage V_b. A metal halide lamp with a power rating of 75 W is operated on the circuit arrangement. The rated lamp voltage is 85 V. The down-converter supplies a sawtooth current with a rated value of 0,88 A. A pulsatory input current flows through MOSFET 10 as well as through measuring resistor R with a time-averaged value of 0,195 A. The resistors 5, 6 and 7 of the electric summation circuit had a value of 12 Mohms, 4,7 Mohms, and 8,25 kohms. The measuring resistor R has a value of 2,75 ohms. A series of measurements was carried out whereby the actual lamp voltage and the accompanying power consumed by the lamp were measured. In a first measurement, the circuit arrangement was operated with a signal S1 as known from the present art, so without dependence on V_L. In a second measurement, the circuit arrangement was operated in accordance with the invention, corrections being made for variations in dissipation in the circuit arrangement owing to variations in the lamp current I_L. The results of the measurements are given in Table I below, in which column 1 relates to the first series of measurements and column 2 to the second series of measurements.

TABLE I

V_b = 385 V	Power load P_L (W)	
V_L	1	2
(V)		
75	73.3	74.5
80	74.0	74.8
85	74,9	75,0
90	75.4	75.2
95	75,7	75,0
100	76,0	74.9
105	76,6	75,0
110	76.7	74.6
115	76,9	74.4

The influence of a disturbance of the supply source voltage V_b was investigated in a third measurement. Results are given in Table II.

TABLE II

V_b (V)	Power load P_L (W)	V_L (V)
345	73,3	91,1
350	73,6	91,2
355	73,9	91,2
360	74,2	91,3
365	74,4	91,4
370	74,5	91,4
375	74,7	91,5
380	74,9	91,5
385	75,0	91,6
390	75,1	91,6
395	75,2	91,6
400	75,2	91,6
405	75,3	91,5
410	75,3	91,5

Claims

1. A circuit arrangement for operating a discharge lamp at a substantially constant power by means of a switch mode power supply having a variable input current and provided with switching means which switch periodically for controlling the input current by means of a drive signal generated in a drive circuit and formed from a signal S1 which is proportional to the input current and a reference signal, which circuit arrangement comprises means for generating the signal S1, characterized in that it comprises means by which the signal S1 is also given a dependence on the lamp voltage V_L.

2. A circuit arrangement as claimed in Claim 1, characterized in that the means for generating the signal S1 comprise an electric circuit for summation of signal voltages which represent the input current and the lamp voltage, respectively.

3. A circuit arrangement as claimed in Claim 1 or 2, characterized in that the electric circuit also serves for summation of a signal voltage representing a supply source voltage.

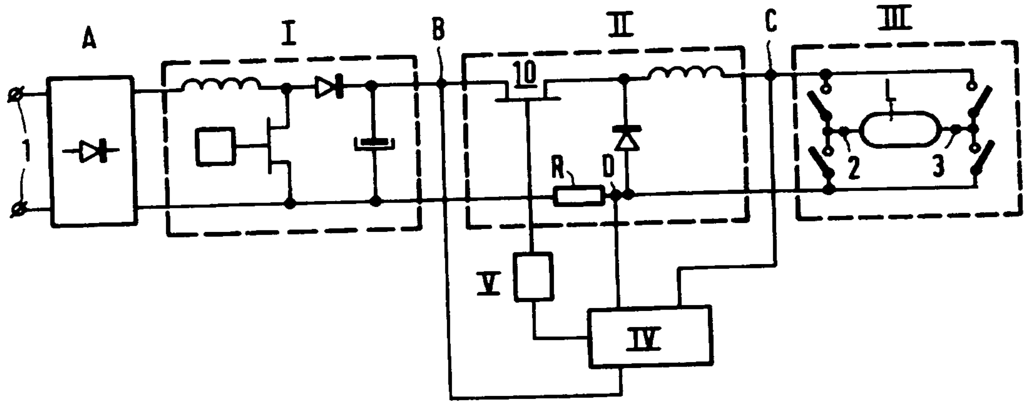

FIG.1

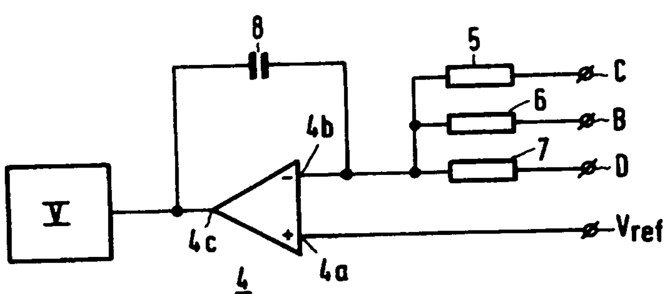

FIG.2